The Unique Estimating Requirements for Unmanned Aerial Vehicles

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Presentation Outline

- Background
- UAV Estimating Process
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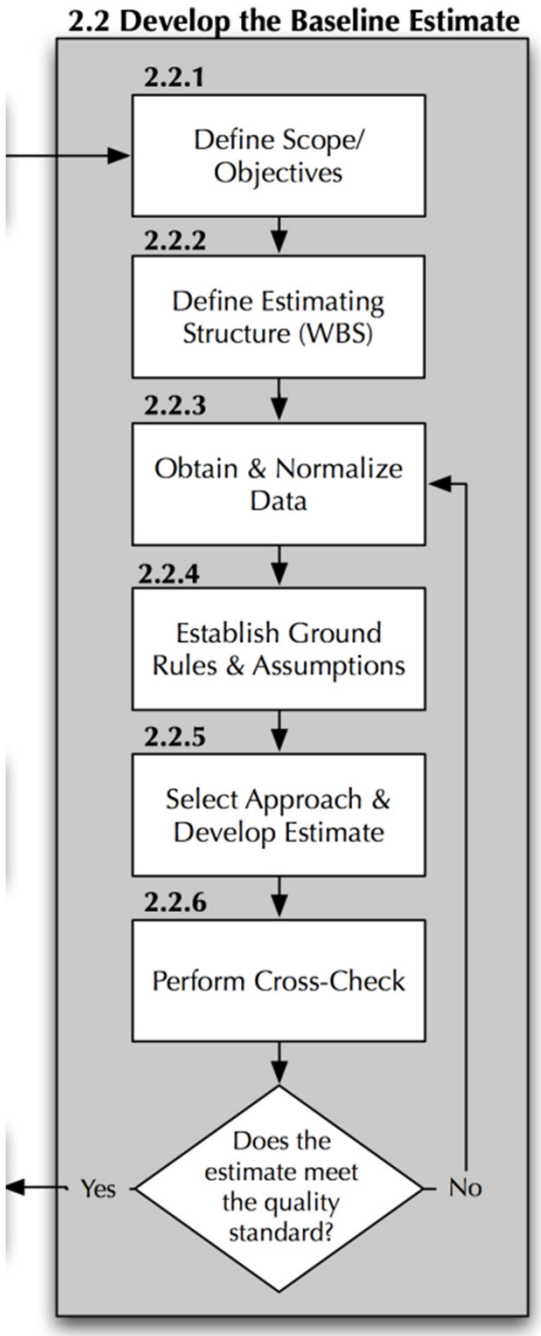
  - Determine Cost Drivers and Sensitivity
  - Obtain and Normalize Data
  - Estimate Hardware Element Costs
  - Estimate Software Module Costs
  - Estimate Operations & Support Costs
- Lessons Learned at Dryden
- Conclusions and Recommendation

All photos courtesy Dryden Flight Research Center

Background

- Why is this topic important?
- Differences in estimating UAVs to aircraft systems
  - Safety standards
  - Aircraft cost less than the payload
  - Digital vs a combination of analog and digital
- Similarities in estimating UAVs spacecraft systems
  - Redundancy
  - Communications



UAV Estimating Process

- Use the estimating process as defined in the 2012 NASA CEH
- Use analogy data from historical UAV projects and related systems
- Use generally accepted estimating methodologies
  - Commercial models
  - Custom developed CERs
  - Factors
- Use multiple methodologies to cross-check estimate

Reference: 2012 NASA Cost Estimating Handbook

UAV Estimating Process

Define Estimating Structure (WBS)

Three choices:

1. DoD MIL-STD-881C, Appendix C (UAV)

2. NASA 7120.5E

3. OEM version (some suppliers use their own which can be based on their way of doing business or on their accrued historical data)

The DoD version is preferred since it makes a better fit to existing cost data and cost models

UAV Estimating Process

Determine Cost Drivers and Sensitivity

- Size (dollars per pound different for handheld UAVs vs. ground launched)
- Level of autonomy (full control vs self-control)
- Level of complexity (use of composite, number of engines, fiber optic control systems)
- Special operating requirements
  - Inflight refueling
  - Carrier operations (landing gear design)
  - Internal vs. external weapons storage (to achieve stealth capability)
  - Other stealth requirements
- Software (amount of legacy design)
- Consider dollars per pound different for each class:
  - Hand-launched
  - Catapult-launched
  - Runway-launched (including carrier)

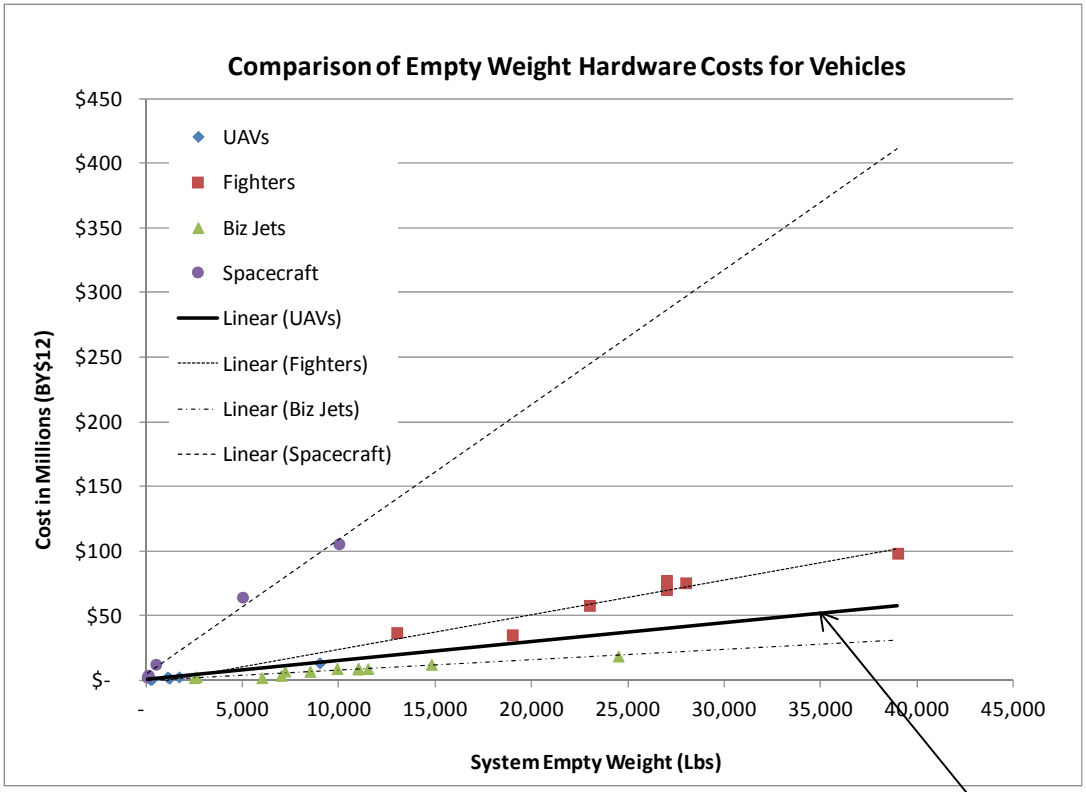
UAV Estimating Process

Obtain & Normalize Data

- Existing UAV airframes and payloads (but consider technology level)
- To offset shortage of UAV data, consider other platforms (but verify compatibility first)
  - Space (COTS antennae)
  - Airborne systems (advanced airframe components, radar and EW payloads)
  - Computers
    - Ground
    - Flight
  - Software
    - Mission
    - Flight
    - Ground control

UAV Estimating Process

Estimate Hardware Element Costs

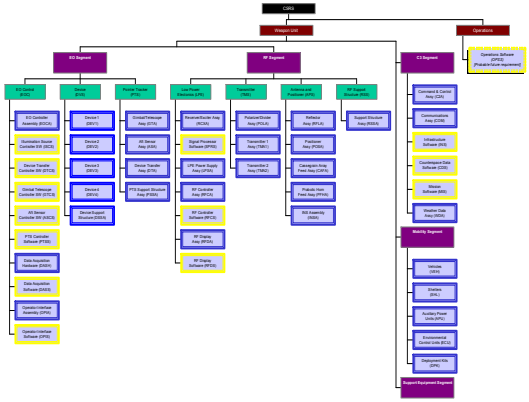


- UAV Estimating Combines attributes of:
  - Fighter Aircraft
  - Spacecraft
  - Commercial Aerospace

Typical UAV Hardware Cost

UAV Estimating Process

Estimate Software Element Costs



WBS	Element Name	Definition
.4	Flight Software	The Flight Software includes all of the operational code required to operate and sustain the spacecraft. The elements listed below comprise the Flight Software.
1.4.1	Executive	Allocates and manages on-board computational resources, performs memory management of command sequences and science data, executes command receipt verification and validation. Performs self-test and gathers and reports health/status at the subsystem level.
1.4.2	Communications	Telecom subsystem, DSN compatible, contains a Small Deep Space transponder, solid-state power amplifier, medium gain X-Band, medium gain UHF, and two low gain antennas. Mostly COTS products.
1.4.3	Command and Data Handling (C&DH)	Includes the flight processor, module interface, input/output, uplink/downlink, payload/attitude control, 6 Gbit mass memory, and DC/DC converter cards.
1.4.4	Power (EPS)	Provides primary power collection, storage, control, and distribution.
1.4.5	Attitude and Control	Includes 3-axis stabilized control system and spin stabilized.
1.4.6	Thermal Control	Thermostatically controlled heater circuits and standard passive features to control the operational temperature of all subsystems throughout the mission.
1.4.7	Spacecraft X-Band Uplink/Downlink	Cruise command sequences are generated and uplinked once every month. Parameter table modifications and final targeting are processed through this link.
.5	Spacecraft Test Laboratory (STL) Software	The Spacecraft Test Laboratory (STL) Software consists of the following items.

Architecture → WBS → Size → Estimate

- SLOC
  - New
  - Reuse
  - COTS integration

- Groundrules and Assumptions
- Model selection
- Input data
- Documentation

- Primary cost driver is size
  - Use consistent definition
  - Determine amounts of new, reused, and modified code
  - Identify applications for COTS products
- Challenges for UAV Software
  - Requires more autonomous code
  - Greater amount of ground-based operational code

UAV Estimating Process

Estimate Operations & Support Costs

- It takes more people to fly an unmanned aircraft than a manned aircraft – unmanned doesn't mean less people
- Both manned and unmanned cockpits need to be maintained
- UAVs are more reliable
- Communications not as expensive

Lessons Learned from Dryden

- Consider cost impact of capability to continue flying when satellite link is lost.
- Consider cost impact of assuring safe operations within the National Air Space (NAS).
- Consider cost impact of achieving the Certificate of Airworthiness (COA).

Conclusions and Recommendations

- UAVs are not special airplanes; they are more likely flying computers.
- UAVs still must comply with aircraft safety and control issues; coordinate flying within the National Air Space.
- Use special WBS, such as recommended in MIL-STD-881C, Appendix C.
- Airborne platform, not an aircraft
- Use caution in performing UAV estimates
  - Selecting platform
- Government sees UAVs having an important future, MIL-STD-881C has it's own unique WBS